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Turning negative memories around: Contingency versus devaluation techniques☆

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ABSTRACT

Background and objectives: It is assumed that fear responses can be altered by changing the contingency between a conditioned stimulus (CS) and an unconditioned stimulus (US), or by devaluing the present mental representation of the US. The aim of the present study was to compare the efficacy of contingency- and devaluation-based intervention techniques on the diminishment in – and return of fear. We hypothesized that extinction (EXT, contingency-based) would outperform devaluation-based techniques regarding contingency measures, but that devaluation-based techniques would be most effective in reducing the mental representation of the US. Additionally, we expected that incorporations of the US during devaluation would result in less reinstatement of the US averseness.

Methods: Healthy participants received a fear conditioning paradigm followed by one of three interventions: extinction (EXT, contingency-based), imagery rescripting (ImRs, devaluation-based) or eye movement desensitization and reprocessing (EMDR, devaluation-based). A reinstatement procedure and test followed the next day.

Results: EXT was indeed most successful in diminishing contingency-based US expectancies and skin conductance responses (SCRs), but all interventions were equally successful in reducing the averseness of the mental US representation. After reinstatement EXT showed lowest expectancies and SCRs; no differences were observed between the conditions concerning the mental US representation.

Limitations: A partial reinforcement schedule was used, resulting in a vast amount of contingency unaware participants. Additionally, a non-clinical sample was used, which may limit the generalizability to clinical populations.

Conclusion: EXT is most effective in reducing conditioned fear responses.

1. Introduction

During fear conditioning a neutral stimulus is repeatedly paired with an aversive event (unconditioned stimulus, US). As result of these pairings, the neutral stimulus becomes a conditioned stimulus, CS, signaling the occurrence of the US. Subsequent CS presentations then result in a preparatory response (conditioned response, CR). Although these anticipatory responses might foster survival, they may become a source of psychopathology in case they persist in the absence of any threat.

Conditioning has been put forward as a powerful theoretical framework to explain the etiology and maintenance of fear, but also provides points of action for fear reduction. For example, exposure therapy is a highly effective treatment method to diminish a conditioned fear response through extinction (Abramowitz, 2013). During an extinction procedure the CS is repeatedly presented in the absence of the US resulting in a diminishment of the CR. Similarly, during exposure a client is confronted with a feared stimulus or situation until the accompanying fear response has been extinguished (Öst, 1996, 1997, 1989).

Several studies have demonstrated that associative learning can occur even if the CS and US are not physically present (e.g., Field, 2006). For instance, pairing an actual CS with a mentally imagined US can result in a CR upon subsequent CS presentations. Likewise, a mentally imagined CS can elicit CRs after being paired with an actual US (Dadds, Bovbjerg, Redd, & Cutmore, 1997). Even more, imagining a CS—US combination, for example imagining a violent dog attacking you, can result in a conditioned fear response. *Vice versa*, mentally exposing yourself to a feared situation can result in fear reductions (e.g., desensitization, Lang & Lazovik, 1963). In sum, these studies indicate that mental experiences with CSs and USs can affect conditioned responding.

☆ The research was conducted at Maastricht University.

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Davey (1997) poses a model in which the strength of the CS—US association not solely depends on the number of CS—US pairings. Accordingly, two processes influence the strength of the CR: expectancy evaluation and US revaluation. The first process concerns the influence of the (expected) contingency between the CS and US on the CR. This process not only reflects direct CS—US experiences, but also reflects expectancy biases, pre-existing beliefs or transmitted information about the CS—US association (e.g., Askew, Kessock-Philip, & Field, 2008; Muris, Bodden, Merckelbach, Ollendick, & King, 2003). The second process, US revaluation, indicates that the mental representation of the US is vulnerable to changes, even if the US itself is not presented. Socially or verbally transmitted information about the US can inflate or devaluate the mental US representation, resulting in, respectively, an increased or decreased CR upon subsequent CS presentations (Davey, 1997; Field, 2006).

The model of Davey (1997) provides several ways to reduce a conditioned fear response. First, contingency-based procedures should affect the strength of the CR. Indeed, extinction or exposure procedures are known to diminish fearful responding. Likewise, a devaluation of the (mental) representation can diminish CRs (Davey, 1989, 1997). Indeed, several studies have indicated that devaluation of the (mental) representation can result in decreased CRs (Dibbets, Poort, & Arntz, 2012). Haesen and Vervliet (2015) explicitly tested the assumption that a conditioned fear response is a combination of the expected probability and estimated intensity of the US. Their results supported this notion. That is, a switch in context after extinction resulted in renewed US expectancies and skin conductance responses (SCRs), whereas a context switch after US devaluation (habituation) only increased US expectancies, but not SCRs. These results support the dual route model posed by Davey (1989, 1997).

Several therapeutic techniques also explicitly tap on this US revaluation procedure, for example imagery rescripting (ImRs) and eye movement desensitization and reprocessing (EMDR). ImRs has been successfully applied in several mental disorders, such as posttraumatic stress disorder (PTSD), personality disorders, social phobia, and depression (Arntz, 2012). During ImRs a person is instructed to mentally relive the aversive event and, next, to change the course of events in a more desired direction (Arntz, 2012). By providing (corrective) information the mental representation of the aversive event is modified. For example, a victim of an aggressive dog attack is asked to mentally relive the aversive event. Subsequently, the person is encouraged to change the course of events by letting the owner leashing the dog during the attack and, as a result, the person has only minor injuries. This altered memory is then retrieved on subsequent occasions, reducing the fear response.

The second technique that is thought to tap on the mental representation of the aversive event is EMDR. EMDR is used to alleviate negative memories and to treat PTSD (Schubert & Lee, 2009). During EMDR a person recalls a traumatic memory while simultaneously making horizontal eye movements (e.g., tracking the therapist's index finger moving from left to right). Subsequent recollection of the traumatic memory is then less vivid and emotional (van den Hout & Engelhard, 2012). Several models have evolved explaining the working mechanism of EMDR. The most supported hypothesis is that EMDR operates by taxing working memory during recall. During recall part of the aversive memory is activated and temporarily located in working memory (WM) (Baddeley, 2003). WM has limited capacity and when two tasks that each tax WM are simultaneously carried out, they compete for this limited capacity. Importantly, it is hypothesized that during recall a memory becomes 'labile', meaning that events during recall influence how the memory is reconsolidated and retrieved in the future (Nader, 2003). As during EMDR the taxation of working memory is thought to result in a less vivid and emotional image, this image is then reconsolidated and recalled on subsequent occasions (see for more hypotheses van den Hout & Engelhard, 2012).

Although both ImRs and EMDR both devaluate the aversive event, their working mechanisms are thought to differ. During ImRs the meaning of the memory is changed according to the needs of the person (Arntz, Tiesema, & Kindt, 2007); while EMDR is thought to change the emotionality and vividness of the memory (Leer, Engelhard, & van den Hout, 2014). However, inherent to the latter technique is that reencountering the aversive event should result in the reinstatement of the affective components of the memory. In case of ImRs the meaning of the aversive event is changed, making it less vulnerable to reinstatement effects.

While the initial acquisition of fear and its subsequent reduction have been extensively examined, to our knowledge no study has compared the efficacy of contingency-versus devaluation-based therapeutic procedures in attempting to reduce fear. Based on the model of Davey (1997) both methods should be effective in reducing a conditioned fear response. However, extinction should explicitly address the US expectancy upon CS presentation, whereas EMDR and ImRs should affect the value of the mental representation of the US. Additionally, EMDR might be more vulnerable upon unexpected US presentations (i.e. reinstatement) than ImRs as it reinstates the affective components of the original memory, whereas during ImRs the rescripted memory remains available. The main aim of the present study is to disentangle the effects of contingency-versus devaluation-based interventions by comparing the efficacy of extinction, ImRs and EMDR on fear diminishment and return of fear.

2. Methods

2.1. Participants

One-hundred and five students (86 females, 19 males) with a mean age of 21.50 years (SD = 2.58) participated. They were randomly allocated to the extinction (EXT, $n = 37$), EMDR (EMDR, $n = 34$), or rescripting (ImRs, $n = 34$) condition. Participation was rewarded with study credits or a voucher of 10 euros. The experiment was approved by the local ethical committee (ECP161 03-06-2015_A2) and carried out in line with the declaration of Helsinki (Williams, 2008).

2.2. Material

2.2.1. Stimuli fear conditioning

Three black and white illustrations of kitchen utilities served as CSs: a chef's hat, a sieve, and a ladle. The fourth stimulus, a colander, was used as practice and filler stimulus. The role of the CSs was counterbalanced across participants. A film clip picturing a kitchen accident was presented (once) to embed the US (https://www.youtube.com/watch?v=-t_fUg0i9sI; duration 30 s, volume about 60 dB). The last 6 s of this film clip, showing the female cook accidentally pouring a pan with boiling water over herself, served as US during the conditioning experiment. To increase the aversiveness of the US the peak volume was set at 105 dB (screaming of the cook). Using a multimodal film clip enables assessment of complex associative fear memories and therapeutic interventions such as ImRs and EMDR (Kunze, Arntz, & Kindt, 2015). The stimuli were presented on a computer screen via E-prime software (Version 2.08, Psychology Software Tools, http://www.pstnet.com).

2.2.2. Questionnaires

2.2.2.1. State-trait anxiety inventory dutch form Y (STAI-DY). The STAI-DY was used to measure state and trait anxiety (Van der Ploeg, 1982). The questionnaire consists of a trait (STAIT) and state (STAIS) subscale. Each subscale comprises 20 items that can be answered on four-point scales (from 'almost never' to 'almost always', total score 20–80). In the present study Cronbach's alpha for the STAIT and STAIS were, respectively, .91 and .84.

2.2.2.2. Modified differential emotions scale (mDES). The mDES consists of 16 items measuring different aspects of emotion. Items can be rated on a Likert scale ranging from one (not at all) to seven (very intense) (Schaefer, Nils, Sanchez, & Philippot, 2010). A negative affect score (mDESneg) was calculated by averaging the eight negative items ("sad, downhearted, blue"; "angry, irritated, mad"; "fearful, scared, afraid"; "anxious, tense, nervous"; "disgusted, turned off, repulsed"; "disdainful, scornful, contemptuous"; "guilty, remorseful"; and "ashamed, embarrassed"); the positive affect score (mDESpos) was calculated by averaging the five positive items Five items ("joyful, happy, amused"; "warm hearted, gleeful, elated"; "loving, affectionate, friendly"; "moved"; and "satisfied, pleased"). Higher scores represented higher levels of negative or positive emotions, respectively (cf. Geschwind, Meulders, Peters, Vlaeyen, & Meulders, 2015).

2.2.2.3. Stimulus ratings

2.2.2.3.1. Film ratings. The total film was rated on pleasantness (0–100 unpleasant to pleasant), valence (0–100, negative to positive) and expectancy (0, unexpected, to 100, certainly expected).

2.2.2.3.2. US ratings. The 6 s clip accompanied by the loud screaming (US) was rated on pleasantness and valence. Furthermore, levels of arousal were measured (all measures: 0 to 100). From the second rating on the change in evoked arousal was measured (0–100, decrease to increase).

2.2.2.3.3. Mental US ratings. After recall five aspects of the mental US representation were questioned: the amount of details and vividness, the evoked tension and averseness, and the experienced negativity. The scale ranged from 0 (not at all) to 100 (very).

2.2.3. Differential fear conditioning task

The fear conditioning task was carried out over two consecutive days. Day one consisted of a practice phase, an acquisition phase and an extinction/intervention phase. On day two, reinstatement took place. For all phases, stimuli were randomly presented and stimulus order varied across participants.

2.2.3.1. Practice phase. The practice phase consisted of three CS0 trials to familiarize participants with the US expectancy ratings. CS0 and an accompanying Visual Analogue Scale (VAS) were presented for 6000 ms. The participant could indicate the US expectancy by clicking on a scale ranging from "certainly not" to "certainly". The inter-trial interval varied between 7000 and 15000 ms (*M*: 11000 ms). CS presentations and US expectancy ratings were identical for all phases of the task.

2.2.3.2. Acquisition phase. During acquisition CS1, CS2 and CS3 were all presented eight times. In six out of 8 trials CS1 and CS2 were followed by the US; CS3 was never reinforced. The US was presented directly after CS offset.

2.2.3.3. Extinction and intervention phase. During the first part of the extinction phase CS0 and CS3 were each presented eight times. Normally the non-reinforced CS- is part of the extinction session. However, to prevent potential differences in (residual) association strength before test, CS3 was presented in all conditions, separating CS1 and CS3 in time for the extinction condition. Next, the extinction condition (EXT) received 16 unreinforced CS1 presentations, whereas the other conditions (ImRS and EMDR) received their intervention. CS2 was not presented in order to measure generalization effects of the intervention at test. The intervention time was for all conditions approximately 5 min.

2.2.3.4. Reinstatement and test. During the reinstatement phase US was presented once followed by two blocks of CS1, CS2 and CS3 trials (6 test trials in total).

2.2.4. Interventions

2.2.4.1. EMD. During the EMDR intervention the participant vividly recalled the most aversive image of the US while, at the same time, following a horizontally moving light grey dot presented against a black background (1 cycle per second). The participant received eight EMDR trials, each lasting 24 s. Trials were spaced by 10 s breaks in which the participant was encouraged to recall the aversive image.

2.2.4.2. ImRs. The participant received a written script about a plausible course of events following the accident. In this script the participant sooths the victim, cools her face with wet towels and a medical team specialised in burn victims arrives. After skin grafts, the victim recovers well. We explicitly included the US for two reasons. Firstly, activation of the mental representation of the event is beneficial for alterations in the (retrievability) of the memory (e.g., Ehlers et al., 2002; Foa & Rothbaum, 1998). Secondly, presentation of the US during the reinstatement phase should not affect its valence as the US is part of the rescripted scene. After reading the script, the participant closed his/her eyes, recalled the US and rescripted the memory by using instructions presented via headphones. The rescripting was repeated twice, resulting in three trials in total. Trials were separated by 5 s breaks; each rescripting trial lasted about 64 s.

2.3. Procedure

See supplementary material for a flowchart. The participant filled in the informed consent, STAIS and STAIT. Subsequently, the skin conductance electrodes were attached and the participant watched and rated the complete 30 s film clip (film ratings and mDES#1). Then, the US (6 s, volume 105 dB) was presented via headphones and rated (USrating#1). The experimenter guided the participant through the practice phase and left the room. After the acquisition phase the participant rated the US (USrating#2). Next, the experimenter encouraged the participant to close his or her eyes and to vividly relive the US as if it was happening at that particular moment with as many details as possible and to rate this mental image (MentalUS#1). A second mDES, concerning the mental US recall was answered (mDES#2) and the extinction/intervention phase was started. After the intervention the participant mentally recalled and rated the US (MentalUS#2) and completed the accompanying mDES (mDES#3).

The next day the participant returned (see for influence sleep on extinction Pace-Schott, Germain, & Milad, 2015). The electrodes were attached and the participant rated the recalled US (MentalUS#3), and the emotional state concerning the mental US (mDES#4). The US and reinstatement test were presented and the participant gave a final rating of the mental representation of the US (MentalUS#4) and accompanying mDES (mDES#5). The participants were debriefed after testing the last participant.

2.4. Data analyses

2.4.1. Expectancy and stimulus ratings

Expectancy ratings were transformed to percentages: 0% indicating no US was expected and 100% that the US would certainly follow. The ratings were averaged across two trials. Only participants that displayed discrimination learning during the acquisition (CS1 and CS2 ratings > CS3 ratings) were included in the data analyses. This selection was made as discrimination is a prerequisite for examining changes in US expectancies at test.

2.4.2. Skin conductance response (SCR)

SCRs to the conditioned stimuli were analysed using Ledalab (V3.2.4; http://www.ledalab.de). Pre-processing included smoothing (8 Gauss, convolution with a Hanning window) and down sampling to 10 Hz. Artefacts were manually traced and corrected using a spline interpolation. Next, a continuous decomposition analysis was run, optimizing the fit and reducing the error of the model (Benedek & Kaernbach, 2010). Skin conductance responses were level-corrected by subtracting the average skin conductance level of the preceding and succeeding inter-stimulus intervals. Subsequently, event-related activation based on the event-locked markers was calculated by using the largest deflection in conductance between 900 and 4000 ms after the stimulus onset (First Interval Response) with a minimum response of .02 µs. The data were range corrected by dividing each participant's SCR by her maximum response (Lykken & Venables, 1971), in this experiment the highest US response (largest deflection 900–4000 after US onset). A square root transformation was applied to normalize the distribution (Siddle & Packer, 1987). The corrected SCRs were averaged across two trials.

2.4.3. Statistical tests

The SCR, US expectancy ratings and stimulus ratings were analysed using GLM repeated measures, with stimulus (CSs+ and CS-) and time or trial block as within-subjects factors and intervention condition (EXT, EMDR and ImRs) as between-subjects factor. In case of an interaction effect, main effects are not reported. The standard rejection criterion was set at $p < .05$ throughout.

3. Results

3.1. Included sample and missing values

Ten female participants dropped out during the experiment. One due to equipment failure and nine indicated that the US was too aversive. Nineteen participants were labelled as contingency unaware; the remaining 76 participants were included in the data analyses. The demographic information of the included sample and questionnaire data are presented in Table 1. There was no difference between conditions regarding age, STAIT, STAIS and initial CS ratings (CSratings#1), $Fs < 1$; neither did the gender ratio vary across conditions, $\chi^2 < 1$.

3.2. Film and US measures

The total film was rated as unpleasant and negative, one sample *t*-test, $ts(75) < -8.85$, $ps < .001$. The accident in the film was, probably due to instructions, expected, $t(75) = 5.96$, $p < .001$. A GLM repeated measures of the mood ratings after the film (mDESpos#1 and mDESneg#1) indicated a more negative than positive mood, $F(1, 73) = 20.65$, $p < .001$, $\eta\rho^2 = .22$, no (interaction) effect of condition was observed, $Fs < 1.36$, $ps > .26$, $\eta\rho^2 < .036$.

The US (6 s clip + loud scream of 105 dB) was rated (USrating#1) as highly unpleasant, negative and startled the participant, $|ts| > 14.74$, $ps < .001$. No group differences regarding the film and US measures were observed, $Fs(2, 73) < 1.59$, $ps > .21$. These results indicate that the film and US were experienced as unpleasant.

3.3. Fear conditioning

3.3.1. US expectancy ratings

3.3.1.1. Acquisition. The acquisition and extinction data are presented in Fig. 1. The GLM repeated measured revealed a stimulus x trial interaction $F(6, 438) = 103.11$, $p < .001$, $\eta\rho^2 = .59$. GLMs per stimulus indicated that, as expected, CS1 and CS2 ratings increased, $Fs(3, 225) > 41.66$, $ps < .001$, $\eta\rho^2 > .35$, and CS3 ratings decreased, $F(3, 255) = 73.00$, $p < .001$, $\eta\rho^2 = .49$, across trial blocks. On the last trial block, CS3 received lower US expectancy ratings compared to CS1 and CS2, $ps < .001$; no difference was observed between CS1 and CS2, $p = .70$.

3.3.1.2. Extinction. The GLM of the EXT condition indicated that, as expected, the CS1 ratings declined across trials, $F(7, 168) = 33.58$, $p < .001$, $\eta\rho^2 = .58$.

Table 1
Demographic information and mean scores (+SD) for the questionnaires and stimulus ratings per condition.

	EXT (n = 25)	ImRs (n = 25)	EMDR (n = 26)
Age	21.68 (2.68)	21.44 (2.86)	21.08 (2.04)
m/f	4/21	5/20	7/19
STAIT	32.44 (6.04)	33.88 (5.64)	33.31 (7.46)
STAIS	39.04 (9.28)	37.60 (7.37)	39.15 (10.60)
Film ratings			
Unpleasant	33.36 (24.09)	24.72 (19.19)	25.77 (21.57)
Negative	26.40 (23.39)	18.60 (15.85)	22.88 (221.73)
Unexpected	71.20 (30.29)	68.80 (25.56)	67.31 (28.68)
USratings#1			
Pleasant	13.80 (21.66)	13.23 (29.65)	9.04 (16.85)
Valence	11.20 (13.94)	5.80 (9.09)	12.12 (16.62)
Startled	78.40 (22.11)	82.60 (19.53)	83.08 (13.57)
USratings#2			
Pleasant	7.60 (14.51)	8.04 (20.84)	13.65 (23.35)
Valence	7.20 (11.00)	4.60 (7.63)	9.62 (17.08)
Change aversive	56.20 (29.27)	64.76 (24.15)	52.88 (26.16)
Change startle	45.60 (23.06)	52.80 (22.13)	43.08 (21.36)
Mental US ratings#1			
Detail	68.60 (20.29)	72.00 (14.22)	69.85 (22.83)
Vividness	75.80 (15.12)	74.20 (17.54)	78.27 (13.63)
Tense	55.20 (21.19)	58.20 (22.40)	55.77 (25.95)
Unpleasant	64.80 (25.68)	64.00 (25.33)	61.15 (27.65)
Negative	73.00 (27.16)	79.88 (20.10)	75.96 (23.50)
Mental US ratings#2			
Detail	53.40 (22.30)	62.80 (16.96)	62.96 (20.27)
Vividness	56.00 (21.84)	63.20 (22.68)	65.23 (17.36)
Tense	39.00 (24.15)	41.20 (25.55)	40.58 (24.26)
Unpleasant	45.60 (25.87)	47.32 (26.05)	45.19 (27.29)
Negative	56.80 (26.57)	58.52 (29.08)	63.65 (25.75)
Mental US ratings#3			
Detail	55.40 (20.91)	58.80 (14.09)	61.15 (22.46)
Vividness	56.00 (18.99)	55.60 (18.95)	66.35 (17.53)
Tense	42.80 (20.57)	38.20 (21.93)	38.85 (23.85)
Unpleasant	46.20 (25.05)	50.20 (23.21)	49.23 (26.63)
Negative	61.40 (23.96)	63.20 (20.36)	65.19 (24.02)
Mental US ratings#4			
Detail	71.00 (18.09)	68.40 (15.53)	71.15 (20.21)
Vividness	75.80 (15.66)	70.72 (18.96)	75.81 (17.78)
Tense	57.60 (20.42)	51.72(24.40)	49.62 (29.90)
Unpleasant	63.20 (24.23)	56.20 (25.43)	56.73 (28.88)
Negative	67.52 (26.35)	69.60 (24.06)	65.96 (27.06)
mDES ratings #1			
Positive	2.10 (.89)	1.88 (.58)	2.09 (.74)
Negative	2.39 (.92)	2.67 (.81)	2.75 (1.05)
mDES ratings #2			
Positive	1.74 (.49)	1.56 (.49)	1.75 (.59)
Negative	2.92 (1.00)	2.86 (.93)	2.92 (.99)
mDES ratings #3			
Positive	1.58 (.70)	1.51 (.49)	1.56 (.46)
Negative	2.16 (.83)	1.97 (.68)	2.14 (.88)
mDES ratings #4			
Positive	1.54 (.59)	1.28 (.31)	1.66 (.85)
Negative	2.08 (.81)	1.79 (.68)	1.95 (.88)
mDES ratings #5			
Positive	1.58 (.66)	1.32 (.38)	1.51 (.55)
Negative	2.32 (.97)	1.98 (.79)	2.21 (1.00)

EXT = Extinction; ImRs = Imagery Rescripting; EMDR = Eye Movement Desensitization and Reprocessing; STAIT = State-Trait Anxiety Inventory Trait subscale; STAIS = State-Trait Anxiety Inventory State subscale; CS = Conditioned Stimulus; US = Unconditioned Stimulus; mDES = Modified Differential Emotions Scale.

3.3.1.3. Reinstatement. Fig. 2 depicts the US expectancy ratings during the reinstatement for all three conditions. The GLM revealed a stimulus x condition interaction, $F(4, 146) = 4.95$, $p = .001$, $\eta\rho^2 = .12$. An ANOVA revealed only for CS1 an effect of condition, $F(2, 73) = 5.07$, $p = .009$, no other effects were observed, $Fs(2, 73) < 2.10$, $ps > .13$. Post-hoc tests indicated that the EXT condition gave lower US expectancy ratings than the EMDR condition, $p = .002$, and

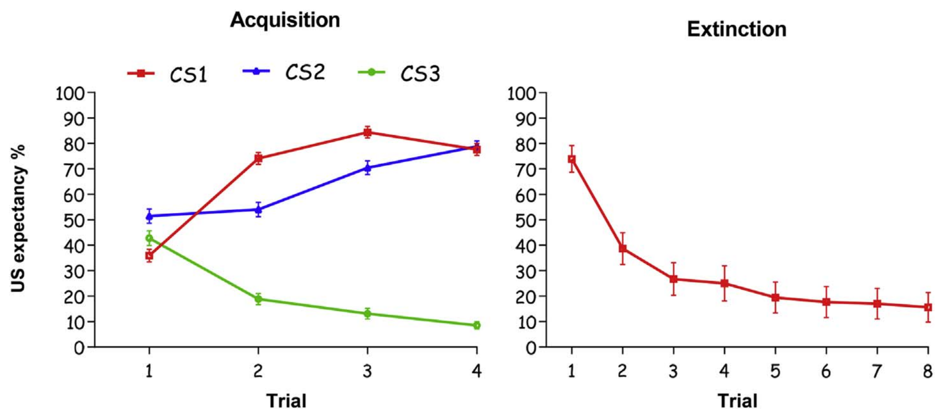

Fig. 1. Mean US expectancy ratings and SEMs during the acquisition (left) and extinction (right).

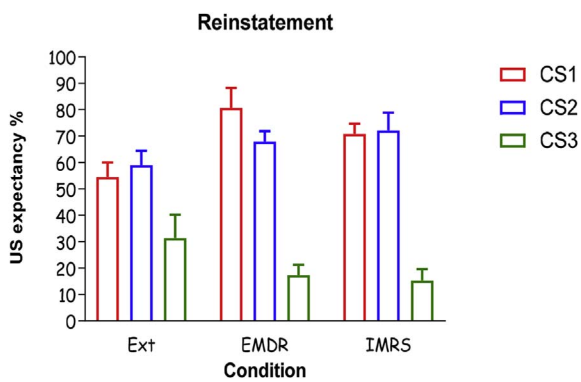

Fig. 2. Mean US expectancy ratings and SEMs during the reinstatement test.

marginally lower than the ImRs condition, $p = .054$; the ImRs and EMDR groups did not differ, $p = .24$.

3.3.2. US ratings

The GLM of the US pleasantness ratings (USratings#1 and USratings#2) revealed no effects, $Fs < 2.22$, $ps > .11$, $\eta\rho^2 < .058$. The GLM of the valence ratings yielded a main effect of time, $F(1, 73) = 8.35$, $p = .005$, $\eta\rho^2 = .10$, with the US becoming more negative over time, indicating sensitization rather than habituation.

3.3.3. Mental US measures

3.3.3.1. Pre-versus post intervention

3.3.3.1.1. Mental US ratings. The mental representation of the US was questioned before (MentalUS#1) and after (MentalUS#2) the intervention. All aspects decreased, $Fs(1, 73) > 25.86$, $ps < .001$, $\eta\rho^2 > .26$, indicating that the mental US representation became overall less aversive. No (interaction) effects of condition were observed, $Fs(2, 73) < 1.67$, $ps > .19$, $\eta\rho^2 < .044$.

3.3.3.1.2. MDES ratings. The GLM on the mood ratings (mDES#2 and mDES#3) revealed a significant interaction between type of mood (positive or negative) and time, $F(1, 73) = 64.87$, $p < .001$, $\eta\rho^2 = .47$. No (interaction) effects of condition were observed, $Fs < 1.03$, $ps > .36$, $\eta\rho^2 < .028$. Separate GLMs indicated that both the positive and negative mood decreased over time, $Fs(1, 75) > 9.18$, $ps < .0034$, $\eta\rho^2 > .11$; both before and after the intervention more negative than positive emotions were reported, $Fs(1, 75) > 34.72$, $ps < .001$, $\eta\rho^2 > .31$.

3.3.3.2. Day 2

3.3.3.2.1. Mental US ratings. The next day the mental US ratings (MentalUS#3) did not differ from the previous day (MentalUS#2), $Fs(1, 73) < 1.94$, $ps > .17$, $\eta\rho^2 < .026$, but remained significantly lower compared to pre-intervention ratings, $Fs(1, 73) > 30.80$, $ps < .001$, $\eta\rho^2 > .29$. No main or interaction effects of condition were observed, $Fs < 2.00$, $ps > .14$, $\eta\rho^2 < .052$. After the reinstatement all aspects of the US representation (MentalUS#4) increased compared to pre-reinstatement ratings, $Fs > 4.53$, $ps < .05$, $\eta\rho^2 > .058$; no effect of condition was observed, $Fs < 1.95$, $ps > .14$, $\eta\rho^2 < .051$. This increase was substantial and for most aspects the ratings did not differ from the pre-intervention ratings (MentalUS#1), $Fs(1, 73) < 1.68$, $ps > .20$, $\eta\rho^2 < .023$. However, the memory was less negative, $F(1, 73) = 15.41$, $p < .001$, $\eta\rho^2 = .17$, and marginally more pleasant, $F(1, 73) = 3.92$, $p = .051$, $\eta\rho^2 = .051$, compared to the pre-intervention ratings. No effects of condition were observed, $Fs < 1.21$, $ps > .30$, $\eta\rho^2 < .032$.

3.3.3.2.2. MDESratings. The GLM comparing post-intervention (mDES#3) to the pre-reinstatement (mDES#4) mood ratings revealed a main effect of emotion, $F(1, 73) = 42.11$, $p < .001$, $\eta\rho^2 = .37$, and time, $F(1, 73) = 4.58$, $p = .036$, $\eta\rho^2 = .059$. Overall the negative mood received higher ratings than positive mood and both emotional states declined. No other (interaction) effects were observed, $Fs < 1.14$, $ps > .32$, $\eta\rho^2 < .031$. After reinstatement (mDES#5) the negative mood strongly increased compared to pre-reinstatement ratings (mdES#4), $F(1, 73) = 15.30$, $p < .001$, $\eta\rho^2 = .17$, whereas the positive mood ratings remained low, $F < 1$. No effect of condition was observed, $Fs < 1.61$, $ps > .20$, $\eta\rho^2 < .043$. Although the mDESneg#4 was less negative, $F(1, 73) = 66.59$, $p < .001$, $\eta\rho^2 = .48$, and less positive, $F(1, 73) = 20.98$, $p < .001$, $\eta\rho^2 = .22$, than the rating before the intervention (mDES#2).

3.3.4. Skin conductance response

3.3.4.1. Acquisition. The acquisition and extinction data are presented in Fig. 3. The GLM repeated measures revealed a stimulus x trial block interaction $F(6, 420) = 3.90$, $p = .001$, $\eta\rho^2 = .053$. No other interaction effects were observed, $Fs < 1.53$, $ps > .19$, $\eta\rho^2 < .042$. Multiple comparisons indicated that during the first trial block CS1 evoked larger responses than CS2 and CS3, $ps < .001$, but that this pattern changed so that during the last block CS1 did not differ from CS2, $p = .89$, but they both showed increased responses compared to CS3, $ps < .030$, indicating successful discrimination.

3.3.4.2. Extinction. A GLM repeated measures on the CS1 presentations of the EXT group revealed a decline in SCRs across trials, $F(7, 168) = 3.14$, $p < .005$, $\eta\rho^2 = .12$.

3.3.4.3. Reinstatement. The reinstatement data are depicted in Fig. 4. The data of two persons were not included in the reinstatement analyses, one due to equipment failure the other due to movement artefacts (total sample set $n = 74$). The GLM repeated measures revealed only a marginally significant effect of stimulus, $F(2, 142) = 2.73$, $p = .068$, $\eta\rho^2 = .037$, no other (interaction) effects were

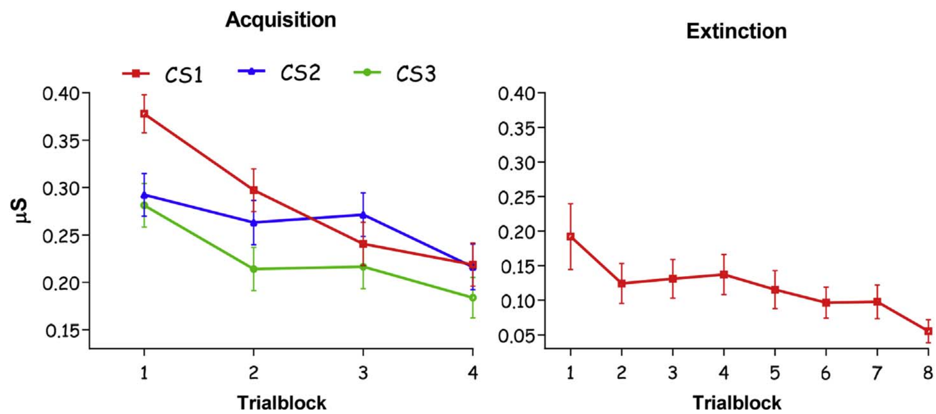

Fig. 3. Mean SCR and SEMs during the acquisition (left) and extinction (right) phase.

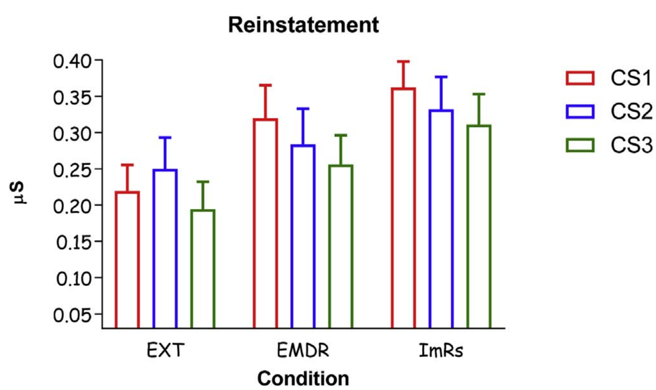

Fig. 4. Mean SCR and SEMs during the reinstatement test.

observed, $Fs < 2.37$, $ps > .10$, $\eta\rho^2 < .063$. Multiple comparisons indicated that, in general, SCRs were larger for CS1 compared to CS3, $p = .016$, and a tendency was observed, though not significant, for larger CS2 than CS3 responses, $p = .089$. No differences were observed between CS1 and CS2, $p = .58$.

As we were explicitly interested in possible differences between conditions for CS1, CS2 and CS3, ANOVAs were carried out per stimulus type. These analyses revealed an effect of condition for CS1, $F(2, 71) = 3.32$, $p = .042$, but not for CS2, $F < 1$, or CS3, $F(2, 71) = 2.06$, $p = .14$. Multiple comparisons for CS1 indicated that SCRs were smaller for the EXT condition compared to the ImRs, $p = .015$, and marginally smaller than the EMDR condition, $p = .077$. No differences were observed between ImRs and EMDR, $p = .45$.

4. Discussion

The aim of the present study was to examine three analogues of well-known therapeutic interventions on the decrease in – and return of fear using a fear conditioning paradigm. The exposure-like intervention, EXT, addressed the contingency between the CS and US; the two other interventions, ImRs and EMDR, aimed at devaluation of the fearful event (film clip, US) itself. During ImRs the course of events after the US was changed, whereas during EMDR the most aversive scene of the US was used for the intervention. We hypothesized that EXT would outperform ImRs and EMDR regarding the contingency-based US expectancies, but that ImRs and EMDR would be more effective in reducing the averseness of mental representation of the US. Additionally, we expected that after reinstatement the mental US representation would be less aversive in the ImRs condition, as the US itself is part of the rescripted scene, compared to EMDR condition.

The results indicated that the US was experienced as highly aversive and did not habituate over the acquisition. In fact, the US was valued more negative after than before the acquisition phase, which is essential as quick habituation of the US might hinder assessment of US devaluation techniques. As expected, during acquisition the reinforced CS1 and CS2 received higher US expectancy ratings than the non-reinforced CS3. For the EXT condition, CS1 expectancies declined during the subsequent extinction phase. The reinstatement results were in line with our expectations and previous research on US devaluation (Haesen & Vervliet, 2015). The contingency-based EXT intervention resulted in lower US expectancy ratings upon CS1 presentations than the EMDR condition and tended to be lower ($p = .054$) than the ImRs ratings.

Both EMDR and ImRs resulted in a decrease in the averseness of the mental representation of the US. Recall after these interventions declined the amount of details, vividness, evoked tension and averseness of the US memory and a decrease in the negative emotions evoked by recall. These results are in line with previous (experimental) results on EMDR (Schubert & Lee, 2009; van den Hout & Engelhard, 2012) and ImRs (Arntz, 2012). However, contrary to our expectations similar results were observed in the EXT group. While unexpected and although the EXT group did not receive specific techniques to alter the mental representation of the US, this observation might also be explained by US devaluation. That is, CS1 presentations trigger the US representation and the subsequent absence of the expected US during extinction training may have weakened the sensory properties of the US representation, resulting in a diminished fear response (Rescorla & Heth, 1975; see for additional information; Vervliet, 2008; but see; Bouton & Bolles, 1979). Likewise, repeated activation of the mental US presentation by the CS might also be considered as imaginal exposure, which can also result in a decrease in (self-reported) fear (Hecker, 1990).

The reinstatement results indicated that most aspects of the mental US representation returned to pre-intervention level, regardless of intervention condition (see exp. 2 Storsve, McNally, & Richardson, 2012 for similar animal results of initial UR resinstament). The results were expected for the EXT and EMDR condition, as re-experiencing the US may strengthen the sensory properties of the US or re-establish the original memory, respectively. However, we did not expect this for the ImRs condition. In this condition the complete US was incorporated, the script started after US offset. However, it might be the case that the unexpected presentation of the US surprised the participant and that the learned script was not available to devalue the renewed US presentation, though other researchers did find effects of positive rescripting on subsequent negative visual material (e.g., heart rate measures, Hagenaars, Mesbah, & Cremers, 2015). However, in the current study a compound of visual and auditory aversive material was used. Participants debriefed that especially the auditory component was aversive. Though the scream might be part of the script, it is likely that such an unpredictable and uncontrollable loud noise results in disruption of performance (Glass & Singer, 1972), making it hard to apply or retrieve the learned script.

The physiological data indicated that the reinforced CSs, CS1 and CS2, evoked larger skin conductance responses than the non-reinforced CS, CS0. During extinction CS1 responses declined. When we take a look at the reinstatement data, we see that the EXT group tended to display lower SCR than the other groups. This is in line with the notion that contingency awareness coincides with conditioned SCRs (Weike, Schupp, & Hamm, 2007; but see; Haesen & Vervliet, 2015). Indeed, the EXT condition also displayed lower US expectancies during the reinstatement than did the other conditions.

The model of Davey (1997) states that both US devaluation and changes in contingency can result in diminished conditioned (fear) responses. The present study partly supports this model. We do see that during the reinstatement the contingency-based US expectancy and SCRs were most reduced in the EXT condition. However, contrary to our expectations the aversive mental representation equally declined across conditions. Though this might be explained by a weakening in the sensory properties of the mental US representation (Rescorla & Heth, 1975) or via imaginal exposure (Hecker, 1990) in the EXT group, it does not explain the lack of effect between conditions after reinstatement. However, one can argue that unexpectedly encountering the US can result in sensitization of the US in all conditions, increasing the conditioned response (Davey, 1997). To assess this possibility it would be interesting for future research to test return of fear via a change in context (Bouton, 2004). This would still enable the assessment of contingency versus devaluation techniques, without presenting the US again. However, in the present study we explicitly used the reinstatement procedure as we thought it would allow for a differentiation between EMDR and ImRs.

Before discussing the limitations, it is important to mention that the participants were well able to carry out the ImRs and EMDR interventions (see supplementary data). However, the procedures used are at the same time one of the limitations. We used a predefined script and the rate of the moving dot was set at a specific pace. This permits a more direct comparison between experiment groups as the intervention time was similar across conditions, but, at the same time, makes the results less generalizable to a clinical setting. During therapy ImRs and EMDR are tailor-made. A therapist helps to create a script, but does not use a pre-recorded script. Likewise, the pace of a moving finger during EMDR is not necessarily steady, but is adjusted on the basis of the tracking abilities of a client. Additionally, rescripting and EMDR are not limited to a set number of trials and time, though several studies have indicated lab-based EMDR sessions can be successful in reducing the vividness and/or the emotionality an aversive memory (Leer et al., 2014; van den Hout, Bartelski, & Engelhard, 2012). Furthermore, the time frame in which the events took place does not resemble a real traumatic experience. In real life a traumatic event is rarely treated the same day. It is even more unlikely that the dreaded event unexpectedly is re-experienced the next day. However, the current experimental set up does allow a comparison between different intervention techniques without interfering variables as type of aversive experience and intervention duration. As such it can contribute to knowledge about acquisition and treatment of fear (see for the usefulness of fear extinction as experimental tool Graham & Milad, 2011).

A second limitation is the number of drop-outs. In total nine participants discontinued the experiment and nineteen participants were labelled as contingency unaware. Although we did not want the US to habituate, a slightly less aversive US might be used for future studies. As especially the loud screaming was reported as aversive and sensitization rather than habituation took place, a lower volume might give similar results. Regarding contingency awareness, we used a partial reinforcement schedule to prevent fast extinction during the non-reinforced reinstatement test. However, for future research we would recommend using a continuous schedule to enhance contingency awareness.

Thirdly, CS3 (CS-) and CS1 (CS+) were spaced in time for the EXT group. This set up differs from other extinction experiments where CS+ and CS- trials are mixed. A sequential presentation of CS- and CS+ might have influenced test results. For example, the prediction error might be smaller if series of non-reinforced CS+ trials are presented in a row; the upcoming and previous CSs are equal, making the series of trials more predictable and, thereby, reducing the amount of surprise. This reduction in prediction error, might in turn, result in less inhibitory learning (Rescorla & Wagner, 1972). In a follow up study it would be interesting to test if this assumption is true by mixing non-reinforced CS+ and CS- trials versus serial presentations of the stimuli.

Another limitation is the lack of a control group that does not show a change in US ratings after the intervention. It is possible that the mere passage of time is responsible for this change; including a no intervention control group would shed more light on this possibility.

A final limitation is that the current study is conducted in two days. This set up does not allow investigating the intervention techniques on consolidated memories as the intervention took immediately place after fear acquisition. Results may be different if the intervention was separated in time from the acquisition, using a three-day protocol.

Although the present study suffers from some limitations, it is the first that directly compares two different working mechanisms that each aim at reducing a (conditioned) fear response. The results indicate that extinction is most successful in changing contingency expectancies, whereas all interventions seem to reduce the mental representation of an aversive event. For future studies we would suggest to examine the combination of these different treatment techniques on fear reduction.

Author contribution

All authors have contributed and consent to this paper and certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jbtep.2018.02.001.

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